

DATATAPE[®]

12-455
FM SYSTEM
CALIBRATOR

TECHNICAL MANUAL



DATATAPE DIVISION

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SECTION I

GENERAL DESCRIPTION

1-1. GENERAL.

1-2. This manual describes the Bell & Howell 12-455 FM System Calibrator and its application as a component in the overall magnetic tape record/reproduce system. The 12-455 FM System Calibrator is referred to as the FM calibrator throughout this manual.

1-3. In frequency modulation recording and reproducing, the amplitude/time relationship of the data input signal is first converted to a frequency time relationship and then recorded on magnetic tape as frequency deviations about the FM center frequency. The rate at which the recorded frequency varies about the center frequency is determined by the frequency of the data signal. To reproduce and recover the data input signal to its original amplitude and frequency is a function of the FM reproduce amplifier. Using only the FM calibrator, the record and reproduce amplifiers may be aligned with a resolution and accuracy approaching those of using a digital counter and digital voltmeter. The FM calibrator, when used, plugs into the monitor meter position of the amplifier mounting case.

1-4. EQUIPMENT DESCRIPTION.

1-5. The FM calibrator is illustrated in figure 1-1 and is constructed on a printed circuit board similar to the other record/reproduce amplifiers. All operating controls and signal input/output connections appear on the front panel as does the light emitting diode (LED) meter/indicator. For the operators convenience, a pin type test lead is provided. However, any 0.080 inch pin plug patch cord or test lead is acceptable.

1-6. On the front panel are a RECORD TEST switch, a RECORD/REPRODUCE switch, and a DEVIATION (0/+40) switch. In addition, BNC connectors are provided for DC IN and DC OUT, and tip jacks for FREQ IN and FREQ OUT.

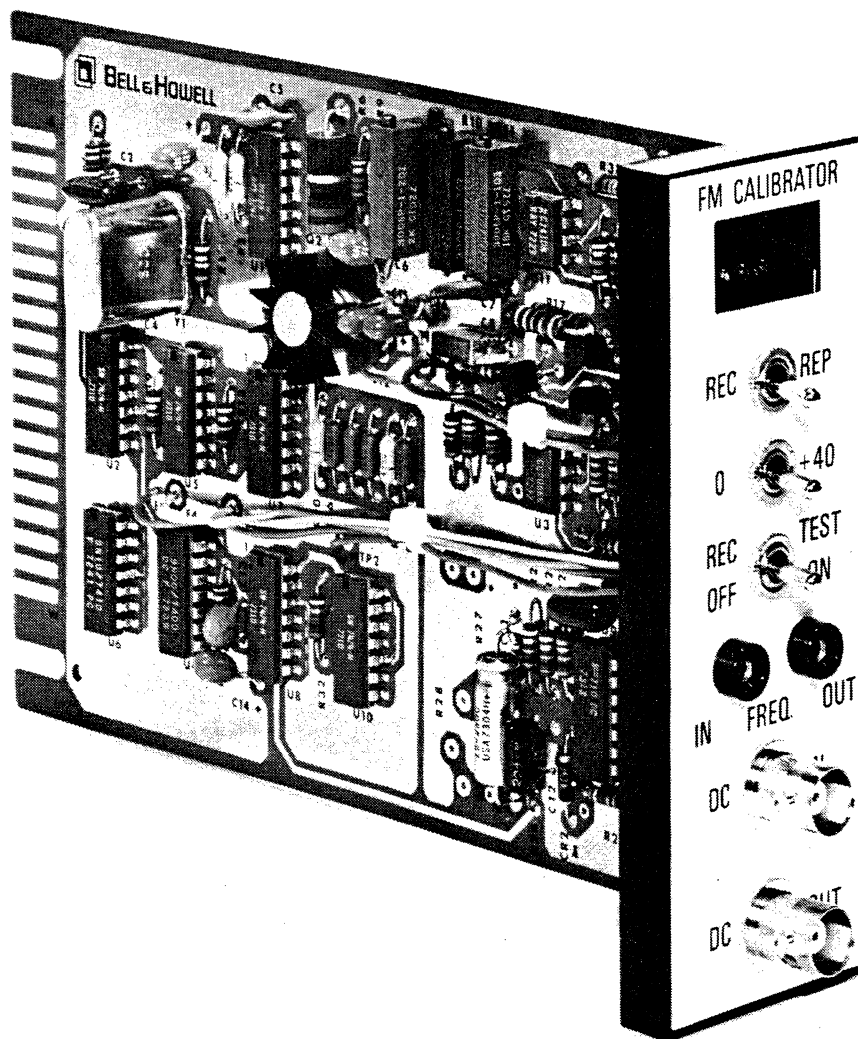
1-7. The meter/indicator consists of four LEDs. A null condition is indicated by all four LEDs being extinguished. When the voltage or frequency being measured is lower than 0.5 percent, both left LEDs light, their intensity being proportional to the error in the measured quantity. As the error is reduced, the intensity of the leftmost LED drops, until only the inner left LED remains lit, which occurs at about -0.5 percent. A positive error is indicated in a similar manner, except that the right LEDs glow. A blue plexiglass filter enhances the indicator contrast and reduces the tendency of ambient light to "wash out" the LEDs.

1-8. PERFORMANCE CHARACTERISTICS.

1-9. Typical performance characteristics for the Bell & Howell 12-455 FM System Calibrator are given in table 1-1.

ITEM	CHARACTERISTIC
DC OUTPUT	0.000 V with 0/+40 switch set to 0. +1.414 V $\pm 0.25\%$ with 0/+40 switch set to +40. R out < 0.25Ω. Noise < 1 mVrms. Current limit approximately 40 mA.
FREQ OUTPUT	54.00 kHz $\pm 0.01\%$ with 0/+40 switch set to 0. 75.60 kHz $\pm 0.01\%$ with 0/+40 switch set to +40. V out: approximately 3 V peak-to-peak from 1KΩ.
DC IN	Accepts the output from an FM reproduce amplifier. With REC/REP switch set to REP, meter indicates null when voltage at DC IN is equal to test voltage at DC OUT. Combined resolution and null accuracy $\pm 0.25\%$. Input resistance greater than 1.0 megohm.
FREQ IN	Accepts 0.1 Vrms or greater for $\pm 0.25\%$ null accuracy. With REC/REP switch set to REC, meter reads null when frequency at FREQ IN is equal to test frequency at FREQ OUT. Impedance is approximately 20K shunted by 20 pF.
OPERATING TEMPERATURE	0° to 60°C.
POWER INPUT	+15 V, 150 mA; -15 V, 50 mA.
PROTECTION	All inputs and outputs are protected to withstand prolonged short circuits and application of dc or peak ac voltage up to ± 25 V.

Table 1-1. 12-455 FM System Calibrator Performance Characteristics



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Figure 1-1. 12-455 FM System Calibrator

SECTION II

INSTALLATION

2-1. GENERAL.

2-2. This section contains the installation procedures for the 12-455 FM System Calibrator.

2-3. CARD PREPARATION.

2-4. Prior to installation, visually inspect the circuit card for impact damage, loose parts, moisture, corrosion, dust, and for any other condition which may impair the life of the calibrator or otherwise degrade its performance. See Section V for repair and maintenance instructions before proceeding with repairs.

2-5. FM CALIBRATOR CARD INSTALLATION AND REMOVAL.

CAUTION

Turn system power OFF before installing or removing amplifier cards from the amplifier case assembly.

2-6. The FM calibrator circuit card is positioned by guide slots in the first position on the left of the amplifier case. This position is also used for the monitor meter assembly.

2-7. With the circuit card positioned in a guide slot, all electrical power connections are completed when the connector end of the circuit card is mated with its connector on the amplifier mother board. The mother board is located in the amplifier case.

2-8. Removal of the FM calibrator may be eased by removing the adjacent card and using the lip of the plastic front panel to obtain a better grip.

CAUTION

Do not pull on the cable, for this may damage the connector/cable interface.

SECTION III

OPERATION

3-1. GENERAL.

3-2. This section describes the procedure for using the FM calibrator in the alignment of a system consisting of a 12-454A FM Record Amplifier and a 12-457G FM Reproduce Amplifier or 12-458 Universal FM Reproduce Amplifier.

CAUTION

Dc connections should be made with coaxial cables fitted with BNC connectors. Do not attempt to use the pin plug cable provided for frequency monitoring, as this may damage the BNC inner connector.

3-3. The FM calibrator requires no warm-up prior to operation. However, the record/reproduce system should be allowed to stabilize for about ten minutes before calibration.

3-4. The function of each control and indicator is summarized in table 3-1.

CONTROL AND INDICATORS	FUNCTION
LED INDICATOR	Indicates proper calibration of the record/reproduce amplifiers. Null illumination of the diodes indicates either center frequency or +40% deviation with the corresponding dc levels is achieved.
RECORD/REPRODUCE SWITCH, S3	Selects whether the calibrator is used in alignment of the FM record or FM reproduce amplifier.
RECORD TEST SWITCH, S1	In the ON position, the FM record amplifiers are energized for alignment purposes without moving tape. In the OFF position, the system operates normally.
0/+40 SWITCH, S2	Provides either a 0 volts or a +1.414 Vdc calibration voltage for alignment of the FM record/reproduce amplifiers.

Table 3-1. FM Calibrator Controls and Indicators

3-5. FM RECORD AMPLIFIER CALIBRATION.

(Figure 4-1)

3-6. The FM record amplifier calibration procedure is as follows:

- a. On the FM calibrator, (1) connect the DC OUT jack to the input connector on the FM record amplifier, (2) connect the FREQ IN jack to the frequency in test point (TP3) on the FM record amplifier, and (3) connect the DC IN jack to the output connector on the FM reproduce amplifier.
- b. Set the transport speed selector switch to the speed which corresponds to a center frequency of 54 kHz. For IRIG WB I extended, set the speed selector to 7-1/2 ips; for WB I 15 ips; for IB 30 ips, and for LB 60 ips.
- c. On the FM calibrator, place the REC/REP switch to REC; the 0/+40 switch to 0, and the REC TEST switch to ON.
- d. Adjust the FM record amplifier center frequency controls, CFc (R5) coarse, and CFF (R6) fine, for a null indication of the LED indicators on the FM calibrator.
- e. Set the 0/+40 switch to +40; adjust the deviation controls ΔF_c (R2) coarse, and ΔF_f (R3) fine, for a null indication of the LED indicators on the FM calibrator.
- f. Place the REC TEST switch to OFF.

3-7. FM REPRODUCE AMPLIFIER CALIBRATION.

3-8. Calibration of the two-speed 12-457G FM Reproduce Amplifier, part number 534655-0001. (Figure 4-2.)

- a. Set the transport speed selector switch to the highest speed for which a filter is installed on the FM reproduce amplifier.
- b. Set the 0/+40 switch to +40. Monitor TP1 on the FM reproduce amplifier with an oscilloscope and while simultaneously recording and reproducing, adjust the head current control, R37, on the FM record amplifier for maximum signal level.
- c. Stop the transport. Turn OFF power to the system. Place the FM reproduce amplifier on an extender board. Turn system power ON.
- d. On the FM calibrator, place the REC TEST switch to ON and the 0/+40 switch to 0.
- e. Monitor TP2 on the FM reproduce amplifier with an oscilloscope and adjust the BALANCE CONTROL R42 on the FM reproduce amplifier for a symmetrical waveform.

NOTE

Waveform may be either triangle or square depending on setting of the filter response switch.

f. Adjust the dc offset control R45 on the FM reproduce amplifier for a null indication of the LED indicators on the FM calibrator.

g. Place the 0/+40 switch to +40 and adjust the FM reproduce level control R69 for a null indication of the LED indicators on the FM calibrator.

h. Select the appropriate transport speed for the second filter.

i. Place the 0/+40 switch to 0 and adjust the center frequency control R56 for a null indication of the LED indicators on the FM calibrator.

j. On the FM calibrator, place the REC TEST switch to OFF. Turn the system power OFF; remove the FM reproduce amplifier from the extender board and reinsert it in its proper place in the amplifier drawer.

3-9. Calibration of the eight-filter 12-458 Universal FM Reproduce Amplifier, part number 534112.

a. Set the transport speed selector switch to 60 ips.

b. Set the 0/+40 switch to +40. Monitor TP1 on the FM reproduce amplifier with an oscilloscope and while simultaneously recording and reproducing, adjust the head current control R37 on the FM record amplifier for maximum signal level. Stop the transport.

c. On the FM calibrator, place the 0/+40 switch to 0 and the REC TEST switch to ON. Adjust the DC OFS controls coarse and fine for a null indication of the LED indicators on the FM calibrator.

d. Place the 0/+40 switch to +40 and adjust the LVL control for a null indication of the LED indicators on the FM calibrator.

e. On the FM calibrator, place the REC TEST switch to OFF.

f. This completes the calibration of the FM reproduce amplifier.

3-10. The FM calibrator aligns the system for full scale deviation (+40%) for +1.414 Vdc input. Therefore, the normal record level will be 1 Vrms with a zero dc component. The FM calibrator may be modified to provide other dc reference and calibration voltages. Contact the Bell & Howell DATATAPE Division Sales and Service Office for information on your particular calibration requirements.

SECTION IV

THEORY OF OPERATION

4-1. GENERAL.

4-2. The frequency modulation method of magnetic tape recording causes data to be recorded on tape in the form of variations in frequency about a center frequency. The amount of deviation from the center frequency is determined by the amplitude of the data signal. The rate of deviation is determined by the frequency of the data signal.

4-3. The function of the FM calibrator is to adjust the center frequency of the FM record amplifier with a 0 Vdc reference and, while simultaneously recording and reproducing, to adjust the output of the FM reproduce amplifier for a 0 Vdc output. Likewise, the FM record amplifier is adjusted for +40 percent deviation from center frequency with a +1.414 Vdc reference provided by the FM calibrator and, while simultaneously recording and reproducing, the FM reproduce amplifier is adjusted for a +1.414 Vdc output.

4-4. CIRCUIT DESCRIPTION.

4-5. Figure 7-1 is a schematic diagram of the FM calibrator. The circuits consist of six basic sections, each of which will be described in the following paragraphs. The basic sections are: power supply, dc reference voltage, frequency reference, dc voltage comparator, frequency comparator, and display.

4-6. Figure 4-1 is a block diagram of the FM calibrator, illustrating the blocks and interconnections with the FM record amplifier for calibrating the FM record amplifier. Figure 4-2 illustrates the block diagram of the FM calibrator and interconnections with the FM record and FM reproduce amplifiers for calibrating the FM reproduce amplifier. Refer to figures 4-1, 4-2, and 7-1 for the following circuit description.

4-7. POWER SUPPLY.

4-8. The integrated circuit regulator U1 and the series pass transistor Q2, together with their associated components, provide a well regulated +5 Vdc source for the digital integrated circuits. The collector and VCC voltages for U1 and Q2 are derived from the transport +15 Vdc power supply via connector P1-3. Connector P1-5 provides the calibrator with -15 Vdc from the transport power supply.

4-9. Transistor Q2 serves as the series pass regulator, reducing the power dissipation in U1 to negligible levels. This, in turn, enables the regulated +5 V at Q2 emitter to be used as a reference for the precision dc voltage reference. Resistor R8 helps to reduce the power dissipated in Q2 and also provides current limiting to prevent damage if the +5 V supply is accidentally shortcircuited.

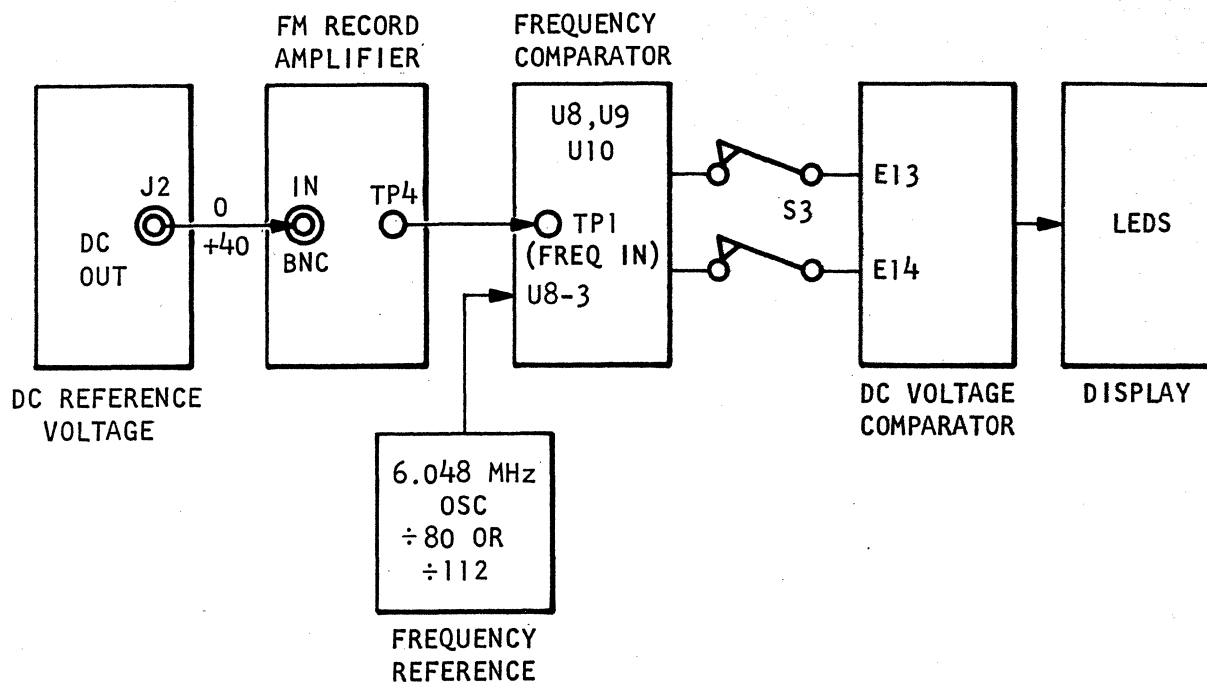


Figure 4-1. Block Diagram, FM Calibrator and Interconnections with the FM Record Amplifier

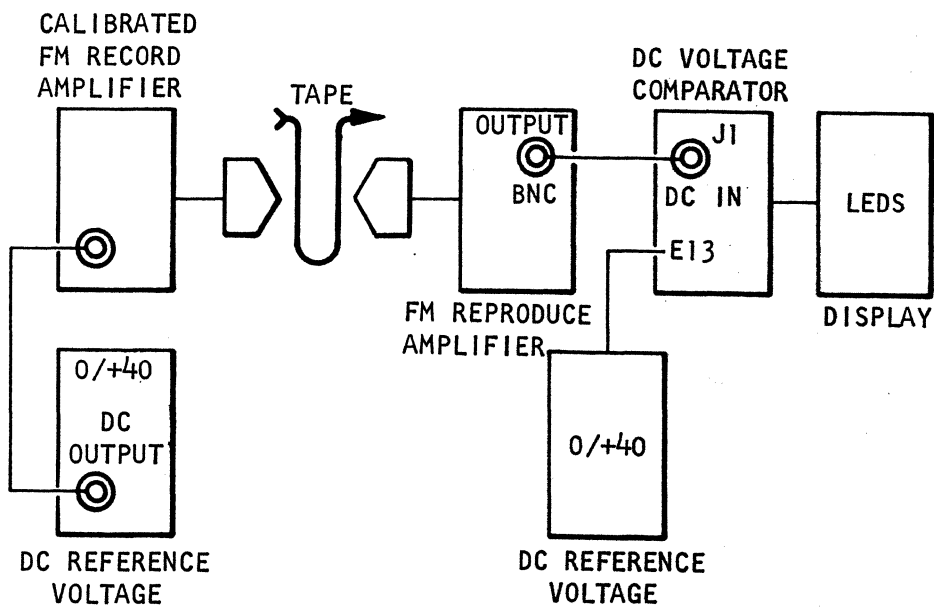


Figure 4-2. Block Diagram, FM Calibrator and Interconnections with the FM Record/Reproduce Amplifiers

4-10. DC REFERENCE VOLTAGE.

4-11. Integrated circuit U3A and transistor Q3 comprise a dc amplifier which buffers the output of the resistive divider R9-R11, to generate a stable, low impedance dc reference voltage. Nominally, the dc reference voltage is set to +1.414 V, but provision is made through the normally unused R12 to set the reference voltage to a higher level. Lower reference voltages may be accommodated by reducing the value of R11. Resistor R17 helps to reduce the power dissipated in Q3 and provides current limiting to prevent damage to U3A or Q3 in the event of accidental shortcircuit.

4-12. FREQUENCY REFERENCE.

4-13. The output of this section establishes the reference frequency outputs of 54.0 kHz or 75.6 kHz. The reference frequency of 54.0 kHz corresponds to the FM center frequency of IRIG Wide Band Group I at a tape speed of 15 ips. The reference frequency of 75.6 kHz corresponds to a +40 percent (full scale) deviation for the aforementioned IRIG group at a normal record level of +1.414 Vdc. Both test frequencies are derived from a single crystal controlled oscillator. Transistor Q1 is connected with a modified Colpitts circuit with crystal Y1 providing precise frequency control at 6.048 MHz. The reference frequency is then divided by either 5 or 7 depending on whether the 0/+40 switch is at +40 or 0, respectively. The divided frequencies, 1.2096 MHz or 864 kHz, respectively, are then further divided by 16 to establish the reference frequency output of 75.6 kHz or 54.0 kHz.

4-14. A high frequency AT-cut crystal is used and counted down to the required operating frequencies. The inherent stability of crystals of this type eliminates the need for an oven or temperature compensation.

4-15. Integrated circuits U2A, U2B, and U5A, together with gates U4A, U4B, U4D, and U6A, form the electrically programmable divider. The use of digital techniques ensures a precise 40 percent frequency difference between the center frequency and the upper deviation limit.

4-16. DC VOLTAGE COMPARATOR.

4-17. Under all conditions, a properly calibrated FM reproduce amplifier should have an output equal to the dc level at the DC OUT jack. The dc comparator consisting of U11 and U3B makes up a high impedance differential amplifier which compares these two voltages. The output of the FM reproduce amplifier is cabled to BNC connector J1 as the DC IN to the FM calibrator and when S3 is in the REP position this DC IN voltage is compared to the DC VOLTAGE REFERENCE at E13. A null condition will be indicated by the LED indicator when the two voltages are equal.

4-18. The potentiometer R41 is adjusted to compensate for the combined offsets of U11 and U3B. A suggested method of adjusting R41 is to cable J2, DC OUT to J1, DC IN and adjust R41 until the LEDs indicate NULL.

4-19. FREQUENCY COMPARATOR.

4-20. The signal at the FREQ IN test point (TP1) is applied to voltage comparator U9, where it is amplified and converted to TTL compatible levels. Positive feedback through R24 provides hysteresis for noise immunity and ensures crisp zero-crossing detection.

4-21. The output of U9 is applied to U8A, where it is synchronized with a signal at four times the test frequency. Synchronization provides further noise immunity and eliminates uncertainties when the input signal is nearly phase coherent with the reference.

4-22. In U8B and U10B, a pulse equivalent in duration to one half period of the test frequency is generated for each cycle of the input signal. When filtered, the pulse train provides a dc level proportional to the input frequency. A similar waveform, generated by counting down the X4 test frequency, provides a reference level with which to compare. It is this differential feature which permits the stability and accuracy required of a calibration instrument.

4-23. When the REC/REP switch is set to REC, the filtered pulse trains are applied to the dc voltage comparator and then to the display.

4-24. DISPLAY.

4-25. The LED display is actuated by the feedback current of the dc comparator amplifier. Operation of this circuit is explained in the following paragraphs.

4-26. Feedback current from the differential outputs of the comparator amplifier flows in such a manner as to make the voltage drop across R40 equal to the difference between the voltages at E14 and E13.

4-27. If E14 is more positive than E13, feedback current flows through CR3, R40, and LEDs λ_3 and λ_4 , illuminating the right, or positive, side of the display. Similarly, if E13 is more positive than E14, feedback current flows through CR4, R40, and LEDs λ_1 and λ_2 , illuminating the left, or negative side of the display.

4-28. For error signals of less than approximately 0.5 percent (7.5 mV), the feedback current is less than one milliamperere. At these low current levels, neither Q4 nor Q5 is biased into conduction, and only LED λ_2 or LED λ_3 is illuminated, depending on polarity.

4-29. At greater error levels, the voltage drop across R44 and R45 biases Q4 or Q5 into conduction. The component of feedback current greater than about one milliamperere is passed through either Q4 and LED λ_1 or Q5 and LED λ_4 , depending upon polarity. As the error signal increases in magnitude, the outer LED intensity rises proportionally until, at about 100 millivolts error, the voltage drop across R42 and R43 causes the amplifiers to saturate, limiting LED current to about 13 milliamperes.

SECTION V

CALIBRATION AND MAINTENANCE

5-1. GENERAL.

5-2. This section of the 12-455 FM System Calibrator manual consists of preventive maintenance, calibration, and troubleshooting and corrective maintenance.

5-3. PREVENTIVE MAINTENANCE.

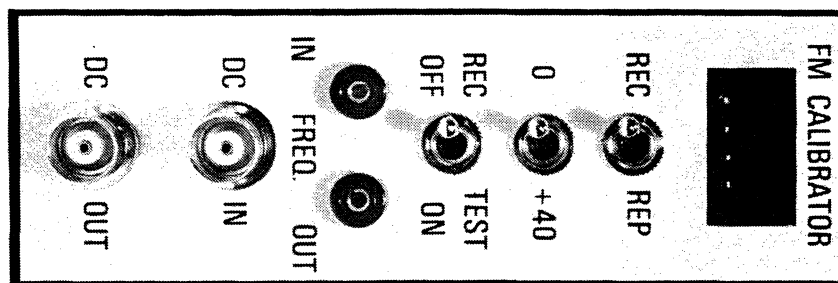
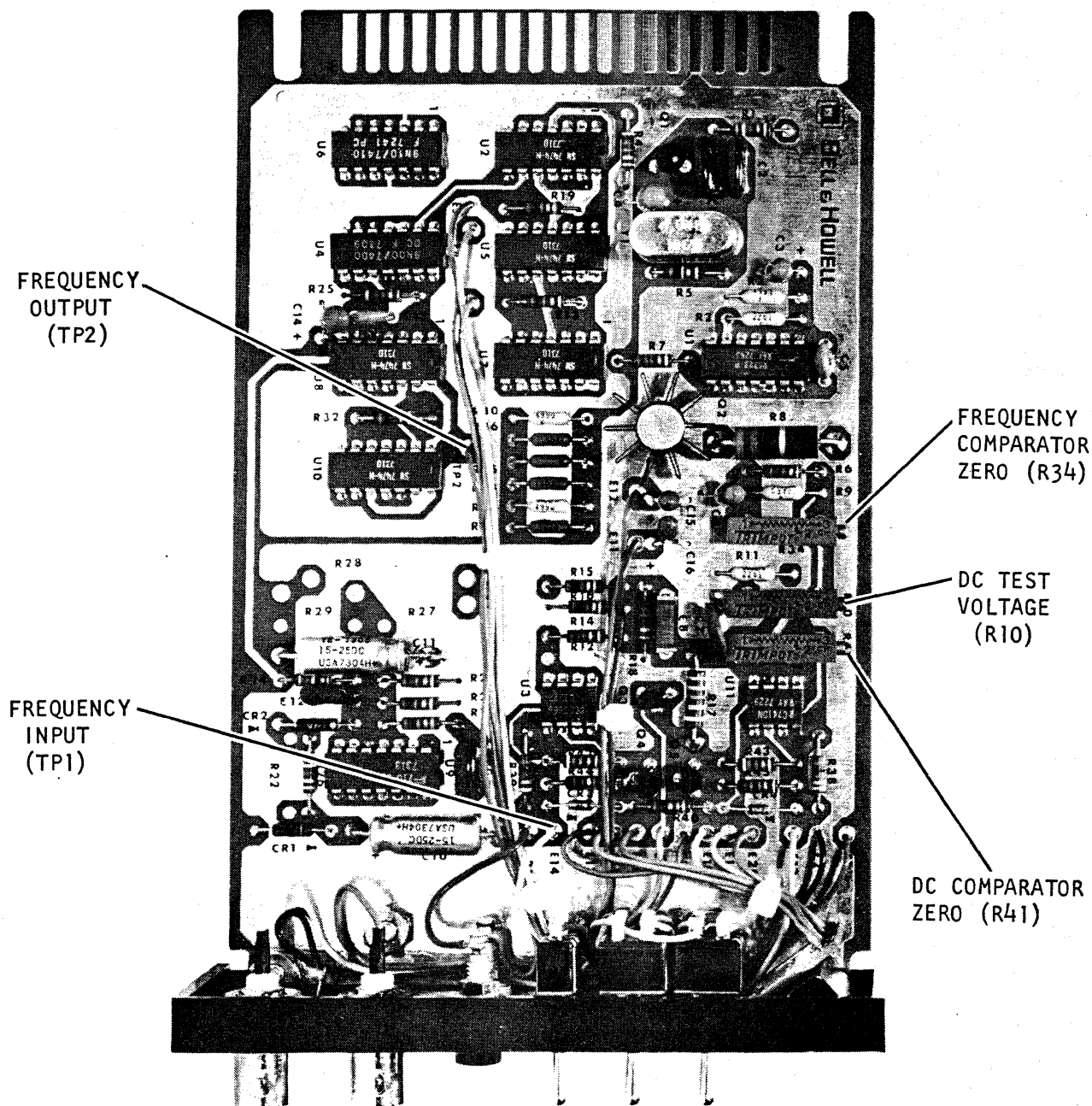
5-4. Preventive maintenance consists of general cleaning and periodic inspection. Accumulation of dust, dirt, grit and/or grease on the printed circuit board is harmful and should be guarded against by periodic inspection and cleaning. Every six months, inspect the units for signs of deterioration, loose connections, insecurity of mounting, and foreign matter. The period of cleaning depends on the particular operating environment and should be determined by inspection. As necessary, clean the circuit board with a soft brush, low air pressure or vacuum, or suitable solvent, being careful not to damage the printed circuitry.

5-5. CALIBRATION.

5-6. The function of each control and test point for the FM calibrator is summarized in table 5-1. The location of each control and test point is shown in figure 5-1.

CONTROLS AND TEST POINTS	FUNCTION
DC Test Voltage, R10	Adjusts the test voltage for full-scale deviation.
Frequency Comparator Zero, R34	Adjusts frequency comparator balance.
DC Comparator Zero, R41	Adjusts dc comparator and display balance.
TP1 Frequency Input	Pin jack used for frequency input.
TP2 Frequency Output	Monitor point for test frequency.

Table 5-1. Controls and Test Points, 12-455 FM System Calibrator



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2779-3

5-7. CALIBRATION ADJUSTMENT PROCEDURES.

5-8. All calibration adjustments are made with the FM calibrator mounted on an extender card. The stability of the FM calibrator is sufficient to permit calibration in an external amplifier test fixture equipped with ± 5 volts to the appropriate pins of the FM calibrator connector. Table 5-2 lists the test equipment required for calibration.

EQUIPMENT	USE
DC Voltmeter: Fluke 825A Differential Voltmeter, Fluke 8100A Digital Voltmeter, or equivalent.	Dc test voltage adjustment.
Frequency Counter: HP5244L, or equivalent	Monitor test frequency.
Sine Wave Oscillator: HP651A, or equivalent	Frequency zero adjustment.
DC Voltage Source: Fluke or stable regulated power supply	Dc zero adjustment.

Table 5-2. List of Test Equipment Required for Calibration Adjustment Procedures

5-9. CALIBRATION CHECK.

5-10. A calibration check is advisable before disturbing adjustments unnecessarily. This check is performed as follows:

a. Using a differential voltmeter, monitor the dc voltage at the DC OUT jack. If desired, a resistor may be used to simulate the record amplifier termination impedance. The dc voltage should be $0.000 \text{ V} \pm 0.0035 \text{ V}$ with the 0/+40 switch set to 0. With the 0/+40 switch set to +40, the dc test voltage should be $+1.414 \text{ V} \pm 0.0035 \text{ V}$.

b. Using a frequency counter with at least 1 Hz resolution, monitor the frequency at the FREQ OUT test point. With the 0/+40 switch set to 0, the counter should read $54,000 \pm 5 \text{ Hz}$. When the 0/+40 switch is set to +40, the counter should read $75,600 \pm 8 \text{ Hz}$.

c. Connect the dc source to the DC IN jack. With the REC/REP switch set to REP and the 0/+40 switch set to 0, adjust the dc source to $-0.1 \text{ V} \pm 0.025 \text{ V}$. Both left LEDs should be illuminated, the leftmost more brilliantly. As the voltage is adjusted toward 0, the intensity of the leftmost LED should fall until, at about -7.5 mV , it will extinguish. As the dc voltage approaches zero, the inner left LEDs intensity should fall, until at $0.000 \text{ V} \pm 0.0035 \text{ V}$ there is no discernible light from any of the LEDs. As the applied voltage goes positive, first the inner right, then both right LEDs should glow. With the 0/+40 switch set to +40, the null indication (all LEDs extinguished) should occur at an input voltage equal to the dc test voltage $\pm 0.0035 \text{ V}$.

d. Connect the sine wave oscillator to the FREQ IN test point. With approximately 1 Vrms into the test point, set the REC/REP switch to REC. With the 0/+40 switch set to 0, the LED indicator should null at $54,000 \text{ Hz} \pm 135 \text{ Hz}$ (0.25 percent). Similarly, with the 0/+40 switch set to +40, null should occur at $75,000 \text{ Hz} \pm 189 \text{ Hz}$.

5-11. If the calibrator outputs and nulls as checked above are within the limits given, the calibrator is within specification and further calibration is not necessary. An out-of-tolerance condition of the frequency outputs or a significant departure from the indicator operation, as described above, are indicative of the need for corrective maintenance. The normal calibration procedure for correctly functioning instruments is described below.

5-12. NORMAL CALIBRATION.

5-13. If the calibration check indicates an out-of-tolerance condition, proceed as follows:

a. Set the 0/+40 switch to +40. While monitoring the dc test voltage at the DC OUT jack, adjust R10 for $1.414 \text{ V} \pm 0.0035 \text{ V}$.

b. Using a BNC-to-BNC cable, patch the DC OUT jack to the DC IN jack. With the REC/REP switch set to REP, 0/+40 switch set to 0, adjust the dc zero control, R41, for an indicated null. The dc zero control has very high resolution, and it may be necessary to interpolate between barely perceptible negative and positive off-null readings. With the 0/+40 switch set to +40, there should be negligible departure from null.

c. Patch the FREQ OUT test point to the FREQ IN test point and set the REC/REP switch to REC and the 0/+40 switch to 0. Adjust the frequency zero control, R34, for an indicated null. When the 0/+40 switch is set to +40, there should be negligible departure from null.

5-14. This completes the normal calibration procedure. When used as described in Section III, the calibrator will set up full deviation (+40 percent) for $+1.414 \text{ V}$, permitting full dynamic range for 1 Vrms sine waves.

5-15. TROUBLESHOOTING AND CORRECTIVE MAINTENANCE.

5-16. Before attempting repair of a unit suspected of malfunction, verify that the symptom is not caused by malfunction of associated equipment such as the power supply,

the amplifier case, intercabling errors, etc. This can be done by substituting a known good unit for the suspected unit, or making continuity checks from unit to unit. If such a check eliminates the associated equipment as a source of trouble, check the adjustments which are detailed in previous paragraphs in this section.

5-17. Once the existence of a defective unit has been established, check it for obviously damaged components, such as burned resistors, or incorrect seating of components. The next step is to verify the proper supply voltage is reaching the unit. If the supply voltage is correct, the faulty stage within the unit can be located by tracing signals from stage to stage.

5-18. The FM calibrator is responsive to normal troubleshooting and maintenance techniques. A brief discussion of fault isolation for each area of the circuit may prove helpful.

5-19. During normal operation, the +5 V (nominal) supply should be 4.9 V $\pm$ 5 percent. Voltages outside this range indicate possible problems. The +5 V supply is most readily monitored at the upper lead of R19 or R13. It is normal for the series pass transistor Q2 to run warm to the touch. If an overload condition is suspected, measure the voltage drop across R8. A voltage drop in excess of 8.25 V is indicative of a fault on the +5 V supply.

5-20. Gross inaccuracy of the dc test voltage is usually symptomatic of a fault in U3A or Q3, or erratic contact in R10. Under normal operating conditions, the voltage at E6 should be equal to the voltage at U3 pin 3, which should be +1.414 V $\pm$ 0.5 V.

5-21. Absence of a signal at the FREQ OUT test point indicates failure of the crystal oscillator or one of the integrated circuits in the countdown chain. Tracing the signal through the chain with an oscilloscope will locate the fault. It is normal for the waveform at Q1 collector to be a series of narrow pulses at 6.048 MHz. At pin 6 of U5A, the frequency should be 864 kHz or 1.2096 MHz, depending on the setting of the 0/+40 switch. A fault in the 0/+40 wiring or in U4 or U6 gating could result in a signal of 756 kHz at U5A pin 6. Four stages of binary division occur between pin 6 of U5A and the FREQ OUT test point.

5-22. Failure of the display to function properly (see calibration check, paragraph 5-10) may be traced to either the dc comparator amplifier or the LED assembly. The LEDs may be checked by injecting an ac signal at the DC IN jack when the REC/REP switch is set to REP and the 0/+40 switch is set to 0. Normally, inserting an insulated wire into the center conductor of the DC IN jack will provide enough 60 Hz body pickup to illuminate all four LEDs. If any LED fails to light, it may be suspected as being open. If all LEDs fail to light, either U3B or U11 may be faulty.

5-23. Erratic operation of the frequency comparator may usually be attributed to U9 or U10. With a 50 kHz sine wave of 100 mVrms or greater, a well defined 4 V p-p square wave of the same frequency should appear at U9, pin 9. A series of constant width pulses of the same exact frequency should appear at U10, pin 9. If there is no output from U9, its supply voltages should be checked. The voltage at pin 11

should be $+12\text{ V} +1.5\text{ V}$, and that at pin 6 should be $-6\text{ V} +2\text{ V}$. Voltages outside of these ranges indicate possible failures of CR1, CR2, or U9. Erratic comparator balance from an otherwise functioning circuit may indicate excessive leakage in C15 or C16.

5-24. An out-of-tolerance condition of the crystal controlled test frequency may be attributed to degradation or failure of Y1, C1, C2, or Q1. If any of these components requires replacement, it may be necessary to reselect frequency determining capacitors C1 or C2. This procedure is described below:

- a. Remove C1 and clean its mounting holes of excess solder.
- b. Insert a 330 pF capacitor in C1 mounting holes, making sure that its leads make contact with the plated through holes.
- c. With the 0/+40 switch set to +40, monitor the frequency at U6, pin 13. This frequency should be 1.2096000 MHz $\pm 121\text{ Hz}$.
- d. If the frequency is too high, substitute a 620 pF capacitor for C1. If the frequency is still too high, increase C2 to the next higher value. Since C2 is nominally 27 pF, this will usually be 30 pF.
- e. If the frequency is too low, use a 180 pF capacitor in C1 mounting holes. If the frequency is still too low, reduce C2 to the next lower value, nominally 24 pF.
- f. Once C2 has been determined, select C1 to bring the frequency as near to 1.2096000 MHz as possible, keeping in mind that the specification tolerance is $\pm 121\text{ Hz}$.

5-25. Once the defective stage has been located, the defective component in that stage can be determined by reference to the circuit descriptions in Section IV and the schematic diagram in Section VII of this manual, and by making continuity, voltage and/or resistance measurements about the suspected components.

5-26. REPAIR.

5-27. Repair of the unit should be attempted only by personnel experienced in printed wiring techniques. It is recommended that repair be limited to replacement of defective parts and adjustment of controls. When removing or replacing defective parts, care should be exercised so as not to damage contiguous parts of the circuit board itself. Replacement parts must be of the correct type and value, as listed in the parts list in Section VI of this manual. When installing a new part, place it in exactly the same position as the replaced part. After replacement, carefully inspect the circuit board for evidence of cold solder joints, solder splashes, and insecurity of mounting. If the equipment is repaired, the FM calibrator should be checked and, if necessary, adjusted as described in the adjustment procedures which are detailed in previous portions of this section.

5-28. PARTS IDENTIFICATION.

5-29. Components of the 12-455 FM System Calibrator are illustrated in Section VI of this manual, showing locations and part designations. The parts list in Section VI itemizes the component parts in the assembly and provides the Bell & Howell part number for each.

5-30. FIELD REPAIR SERVICE.

5-31. Refer to Section V of the system manual for field repair service information.

5-32. FACTORY REPAIR SERVICE.

5-33. Refer to Section V of the system manual for factory repair service information.

SECTION VI

PARTS LIST

6-1. GENERAL.

6-2. An appropriate parts list and illustration for the 12-455 FM System Calibrator follow the instructions given below. The parts list includes the part number, description, figure and index and/or schematic reference symbol, and where applicable, the manufacturer's or military part number for each component. Manufacturers are identified in the parts lists by code number in accordance with the Federal Supply Code for Manufacturers, Cataloging Handbook H 4-2, and as listed in table 6-1. The components are illustrated in figure 6-1.

6-3. ORDERING REPLACEMENT PARTS.

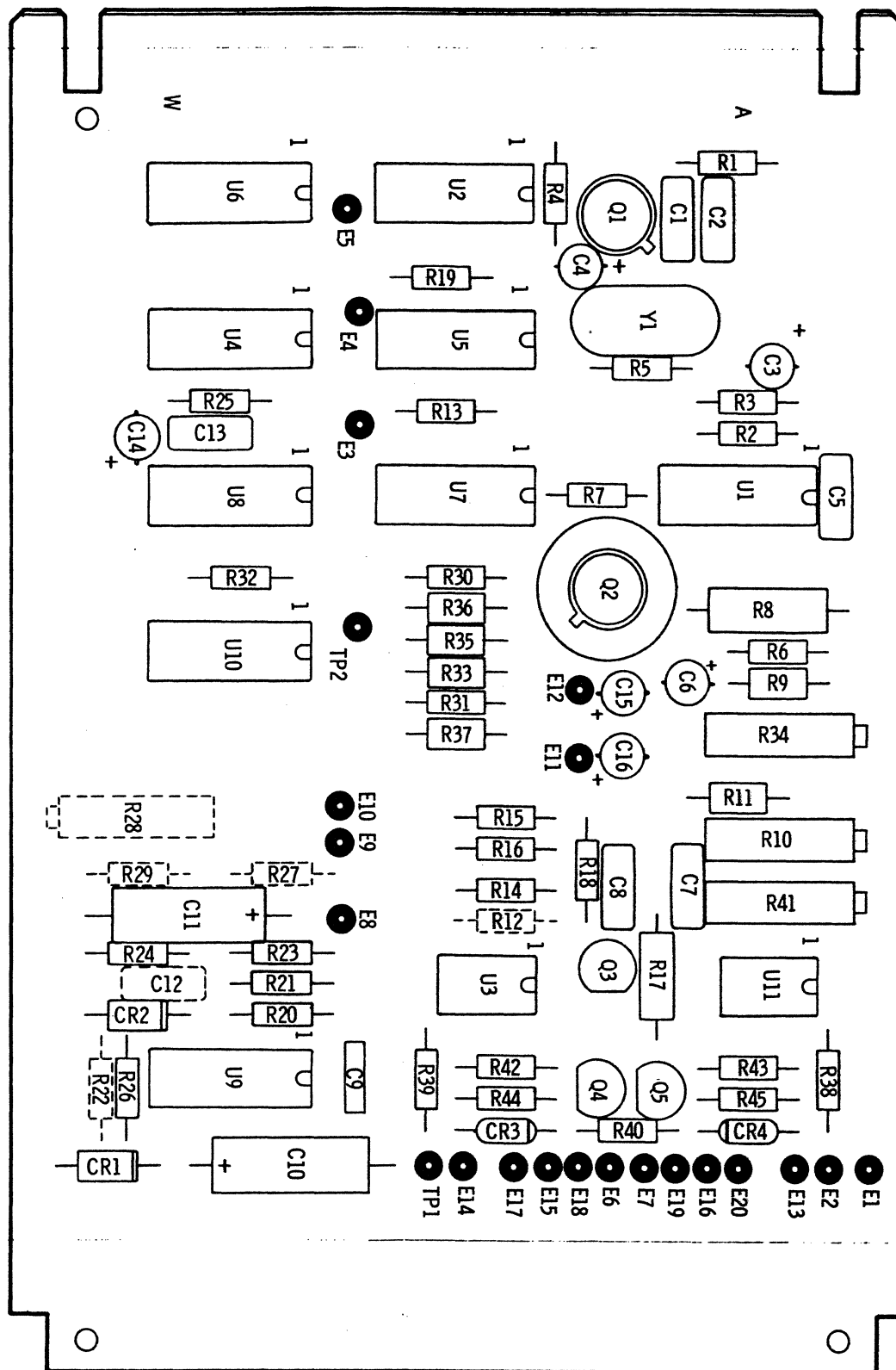
6-4. Parts should be ordered through the nearest Bell & Howell DATATAPE Division Sales and Service Office. Price and delivery information on parts or complete instruments may be obtained there, also. To assist in making this contact, a list of Sales and Service Offices is included in the front of this manual. Bell & Howell recommends that whenever possible, and particularly when an instrument is used in a critical application, the user maintain a minimum stock of spare parts. DATATAPE Division has specialized personnel ready to assist the user in making a selection of spares at any time. The same personnel are also ready and able to prepare or quote on the preparation of illustrated parts breakdowns (IPB's), provisioning parts breakdowns (PPB's), and other parts documentation that might be required.

6-5. When ordering parts, the following information should always be supplied to the field office engineers:

- a. A description of the part or assembly, obtained from the parts list.
- b. The figure and index, and/or reference symbol, given on the applicable diagram and on the parts list.
- c. The part or type number of the major assembly, shown on the instrument nameplate.
- d. The production serial number, also on the nameplate.
- e. The Bell & Howell register number applying to the complete system or order.

CODE	MANUFACTURER
01121	Allen-Bradley Company Milwaukee, Wisconsin
01295	Texas Instruments, Incorporated Semiconductor Group Dallas, Texas
04713	Motorola, Incorporated Semiconductor Products Division Phoenix, Arizona
13715	Fairchild Camera and Instrument Corporation Semiconductor Division Mountain View, California
14028	Bell & Howell Company DATATAPE Division Pasadena, California
32997	Bourns, Incorporated Trimpot Products Division Riverside, California
56289	Sprague Electric Company North Adams, Massachusetts
72136	Electro Motive Corporation Subsidiary of International Electronics Corporation Willimantic, Connecticut
72982	Erie Technological Products, Incorporated Erie, Pennsylvania
91836	Kings Electronics Company, Incorporated Microwave Division Tuckahoe, New York
95146	Alco Electronics Products, Incorporated Lawrence, Massachusetts

Table 6-1. List of Manufacturers



CALAWAY & BROOKS DWG NO. D-6801 (REF)

Figure 6-1. FM Calibrator Assembly

Table 6-2. Parts List for the 12-455 FM System Calibrator (Sheet 1 of 4)

ITEM NO.	0 1 2 3 4	DESCRIPTION	QTY	FIG./INDEX OR REF SYM	MFR OR MFR CODE	MFR OR MIL PART NO.
1		12-455 FM System Calibrator Assy	1		Calaway Elect.	6800
2		Schematic	Ref		Calaway Elect.	6802
3		PC Board Assy	1		Calaway Elect.	6801
4		Printed Wiring Board	1		Calaway Elect.	6803-1
5		Integrated Ckt	1	U1	Raytheon	RC723P
6		Integrated Ckt	5	U2,5,7,8,10	01295	SN7474N
7		Integrated Ckt	1	U3	Raytheon	RC4558DN
8		Integrated Ckt	1	U4	01295	SN7400N
9		Integrated Ckt	1	U6	01295	SN7410N
10		Integrated Ckt	1	U9	13715	ua710DC
11		Integrated Ckt	1	U11	Raytheon	RC741DN
12		Transistor, PNP	1	Q1	13715	2N3640
13		Transistor, NPN	1	Q2	04713	2N2218
14		Transistor, NPN	3	Q3,4,5	04713	MPS5172
15		Diode, zener, 3.3 V $\pm 5\%$	1	CR1	04713	1N746A
16		Diode, zener, 9.1 V $\pm 5\%$	1	CR2	04713	1N757A
17		Diode	2	CR3,4	04713	1N4148
18		Crystal	1	Y1	Calaway Elect.	6821
19		Res, 3.9K $\pm 5\%$, 1/4 W	2	R1,26	01121	RC07
20		Res, 2.26K $\pm 1\%$, 1/4 W	2	R2,11	Mepco	RN55C
21		Res, 4.99K $\pm 1\%$, 1/4 W	1	R3	Mepco	RN55C
22		Res, 470 Ω $\pm 5\%$, 1/4 W	2	R4,25	01121	RC07
23		Res, 100K $\pm 5\%$, 1/4 W	1	R5	01121	RC07
24		Res, 150 Ω $\pm 5\%$, 1/4 W	1	R6	01121	RC07

Table 6-2. Parts List for the 12-455 FM System Calibrator (Sheet 2 of 4)

ITEM NO.	0 1 2 3 4	DESCRIPTION	QTY	FIG./INDEX OR REF SYM	MFR OR MFR CODE	MFR OR MIL PART NO.
25		Res, 2.2K $\pm 5\%$, 1/4 W	2	R7,14	01121	RC07
26		Res, 68 Ω $\pm 10\%$, 1 W	1	R8	01121	RC32
27		Res, 6.81K $\pm 1\%$, 1/4 W	1	R9	Mepco	RN55C
28		Res, var, 2K $\pm 10\%$, 3/4 W	2	R10,34	32997	3006P-1-202
29		Res, 10K $\pm 5\%$, 1/4 W	5	R13,19,20,21, R23	01121	RC07
30		Res, 1K $\pm 5\%$, 1/4 W	5	R15,16,32,38, R39	01121	RC07
31		Res, 330 Ω $\pm 5\%$, 1/2 W	1	R17	01121	RC20
32		Res, 56 Ω $\pm 5\%$, 1/4 W	1	R18	01121	RC07
33		Res, 820K $\pm 5\%$, 1/4 W	1	R24	01121	RC07
34		Res, 499 Ω $\pm 1\%$, 1/4 W	2	R30,31	Mepco	RN55D
35		Res, 10.0K $\pm 1\%$, 1/4 W	4	R33,35,36,37	Mepco	RN55D
36		Res, 7.5 Ω $\pm 5\%$, 1/4 W	1	R40	01121	RC07
37		Res, var, 10K $\pm 10\%$, 3/4 W	1	R41	32997	3006P-1-103
38		Res, 910 Ω $\pm 5\%$, 1/4 W	2	R42,43	01121	RC07
39		Res, 560 Ω $\pm 5\%$, 1/4 W	2	R44,45	01121	RC07
40		Cap, 330 pF $\pm 5\%$, 500 V (nominal select-in-test)	1	C1	72136	DM-15-331J
41		Cap, 27 pF $\pm 5\%$, 500 V (nominal select-in-test)	1	C2	72136	DM-15-270J
42		Cap, 22 μ F $\pm 20\%$, 16 V	4	C3,4,6,14	ITT	TAG 20-22.0/16- 20
43		Cap, 100 pF $\pm 10\%$, 1K V	2	C5,13	72982	CK60B101K
44		Cap, 0.1 μ F $\pm 10\%$, 12 V	1	C7	72982	5655-000Y5F0- 104M

518177-0-1-TM
D170-A10

Table 6-2. Parts List for the 12-455 FM System Calibrator (Sheet 3 of 4)

ITEM NO.	0 1 2 3 4	DESCRIPTION	QTY	FIG./INDEX OR REF SYM	MFR OR MFR CODE	MFR OR MIL PART NO.
45		Cap, 0.1 uF $\pm 10\%$, 250 V	1	C8	Siemens	B32541-0.1/5/ 250
46		Cap, 1000 pF $\pm 5\%$, 100 V	1	C9	72136	DM-15-102J
47		Cap, 15 uF $\pm 10\%$, 25 V	2	C10,11	56289	TE1205
48		Cap, 4.7 uF $\pm 10\%$, 16 V	2	C15,16	ITT	TAG 20-4.7/16- 20
49		Heat Sink	1		Wakefield	205CB
50		Pad, transistor	1		Thermalloy	7717-22
51		Front Panel Assy	1		Calaway Elect.	6808
52		LED PC Board Assy	1		Calaway Elect.	6809
53		Printed Wiring Board	1		Calaway Elect.	6803-2
54		Diode, light emitting	4	$\lambda 1,2,3,4$	04713	MLED50
55		Molding, plastic	1		14028	379381
56		Panel, mtg front	1		Calaway Elect.	6805
57		Panel mtg rear	1		Calaway Elect.	6806
58		Panel, mtg LED	1		Calaway Elect.	6807
59		Window, acetate	1		Calaway Elect.	6820
60		Conn, BNC	2	J1,2	91836	KC79-35
61		Conn, tip jack	2	TP1,2	Pomona	3542 black
62		Switch, SPDT	1	S1	95146	105D
63		Switch, DPDT	2	S2,3	95146	205N
64		Nut, knurled	3		95146	N-1
65		Screw, binder	3			#6-32x5/16
66		Washer, star lock	3			#6
67		Nut	3			#6-32

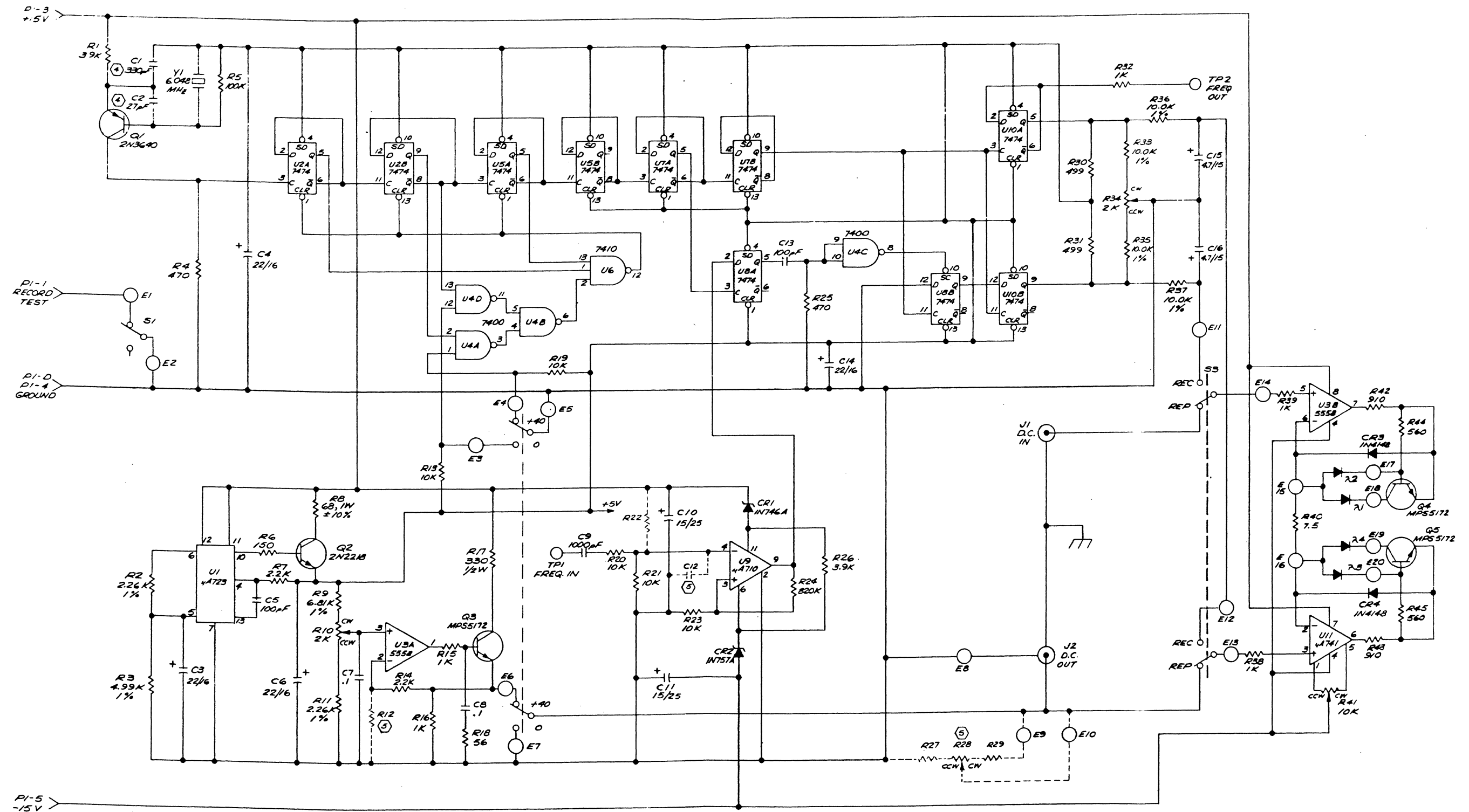
Table 6-2. Parts List for the 12-455 FM System Calibrator (Sheet 4 of 4)

ITEM NO.	0 1 2 3 4	DESCRIPTION	QTY	FIG./INDEX OR REF SYM	MFR OR MFR CODE	MFR OR MIL PART NO.
68		Terminal, lug, #4	1		H.H. Smith	1497
69		Wire, elec, 24 AWG	A/R		Mil-Spec	BU732-24
70		Wire, bus, 24 AWG	A/R		Mil-Spec	24 AWG TC BUS
71		Sleeving, tef, 24 AWG	A/R		Mil-Spec	24 AWG TW Tef. Tub. Nat.
72		Tubing, shrink	A/R		G.C. Elect.	12-1040
73		Cable, tip jack	1		Pomona	PT 080-36 black

SECTION VII
DRAWINGS AND SCHEMATICS

7-1. GENERAL.

7-2. This section contains the schematic drawing, figure 7-1, for the 12-455 FM System Calibrator. All connections shown are part of the amplifier mother board assembly which is covered in the 12-401C Tape Transport manual.



- (S) COMPONENTS SHOWN IN DASHED LINES ARE NOT PART OF STANDARD UNIT.
(*) C1 & C2 ARE SELECT-IN-TEST. VALUES SHOWN ARE NOMINAL.
3 ICs: U2, U4, U5, U6, U7, U8 & U10: PIN 7 TO GND, PIN 14 TO +5V.
2. CAPACITORS ARE EXPRESSED IN $\mu\text{F}/\text{V}$ i.e. 22/16.
1. RESISTORS ARE EXPRESSED IN OHMS (Ω) $\frac{1}{4}\text{W} \pm 5\%$.
NOTES: UNLESS OTHERWISE SPECIFIED

CALAWAY & BROOKS
DWG NO. D-6802 (REF)

Figure 7-1. Schematic, 12-455 FM System Calibrator
7-3/(7-4 blank)